Nokia Solutions and Networks Technical Discussion Paper

FCC Proposed Spectrum Access System for the 3.5 GHz Band

Submitted to the FCC in GN Docket No. 12-354

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Introduction

The Federal Communications Commission ("FCC" or "Commission") is in the midst of developing a regulatory and licensing framework for commercial use of 3550-3650 MHz (referred to as the "3.5 GHz Band"). As part of this open proceeding (GN Docket No. 12-354), the Commission invited the submission of technical papers in advance of a January workshop that would have as a focus potential parameters and characteristics of a Spectrum Access System ("SAS") to facilitate usage of the band for commercial purposes, taking into account existing incumbent users.[1] Nokia Solutions and Networks ("NSN") herein is responding to this call for papers.

Even prior to Commission initiation of this proceeding, NSN has been exploring the potential for commercial use of this spectrum range. Mobile broadband network operators face the challenge of delivering up to 1 GB/user/day and a large increase in the number of connected devices by 2020. In some networks this will require a 1000-fold increase in capacity. To meet this challenge, the industry is considering a ten-fold increase in the number of cell sites of all sizes, a ten-fold increase in the efficiency of use of spectrum and a ten-fold increase in the amount of spectrum available (10x10x10=1000). As a result, NSN believes it imperative that all potential spectrum bands that may help to meet these needs be explored and certainly this includes the 3.5 GHz Band.

Among its attractive attributes, the 3.5 GHz Band has significant appeal because wide blocks of spectrum can be made available, or may be aggregated, to expand the bandwidth capacity of mobile broadband networks. While the 3.5 GHz Band may have some limitations in terms of wide area mobility when contrasted with lower frequency ranges especially in dense areas, it would appear very well suited for small cell deployments in all areas to improve capacity and coverage. The Commission also has the opportunity to allocate the 3.5 GHz spectrum in a manner that would closely align it with globally harmonized 3GPP band plans, which would bring significant benefits to the network and device ecosystems as a large addressable market brings greater economies of scale. Ultimately consumers win in this scenario with access to more capable and affordable devices and services.

NSN previously has submitted multiple rounds of comments to the Commission in this proceeding.[2] In particular, NSN has emphasized ensuring that all entities interested in utilizing the spectrum for quality-of-service ("QoS") type of services be afforded the opportunity. Importantly this includes mobile network operators ("MNOs") facing the rising spectrum demands already noted. NSN continues to believe that the best way to manage access by such entities to spectrum that will continue to have incumbent users, including government radar systems, is through licensed shared access/authorized shared access ("ASA"/"LSA"). ASA/LSA is growing in

[1] Wireless Telecommunications Bureau and Office of Engineering and Technology Call for Papers on the Proposed Spectrum Access System for the 3.5 GHz Band, GN Docket No. 12-354, *Public Notice,* FCC DA 13-2213 (rel. Nov. 18, 2013).
[2] *See, e.g.,* in Docket No. 12-354 Comments (February 20, 2013) and Reply Comments (April 5, 2013) of Nokia Siemens Networks US LLC (responding to the Notice of Proposed Rulemaking); Comments (Dec. 5, 2013) and Reply Comments (Dec. 20, 2013) of Nokia Solutions and Networks US LLC (responding to a Public Notice on a proposed revised licensing framework for the 3.5 GHz Band).

acceptance globally, with industry standardization efforts maturing and technology trials demonstrating its utility.[3] This is why NSN in particular is pleased that the Commission is now proposing to adopt a Priority Access licensing tier that corresponds to NSN's proposed ASA/LSA tier that includes MNOs.

As noted, the focus of the Commission's January workshop, and the corresponding call for technical papers, is the SAS. While this paper takes a somewhat broad interpretation of that scope, the fundamental message is that the Commission should define only the general responsibilities and composition of the SAS with the detailed requirements defined by industry groups and standardization bodies that ideally include participation by the incumbent spectrum users, mobile operators, other potential new users, suppliers, and regulators.
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[3] *See, e.g.,* http://blogs.nsn.com/mobile-networks/2013/05/30/nokia-siemens-networks-accelerates-worlds-first-td-lte-spectrum-sharing-trial-of-asa/.

General Responsibilities and Composition of SAS & Key SAS Functional Requirements

(FCC Focus Areas A and B)

1. SAS or Repository

The Commission's Revised Framework Public Notice (PN)[4] indicated that many of the potential network parameters and RF configurations of systems that would operate in the 3.5 GHz Band were likely to be managed by the SAS.[5] NSN indicated in comments to this PN however its disagreement with this notion, especially for the Priority Access spectrum in 3550-3650 MHz. NSN's view is that the SAS should only identify the available spectrum to authorize use in a particular location/frequency/time, perhaps enhanced with technical requirements such as the interference threshold that should not be exceeded in a given geographical area where the incumbent is operating. The SAS essentially should have the role of the ASA/LSA Repository that NSN presented in its comments to the 3.5 GHz NPRM as shown in Figure 1 below.[6]

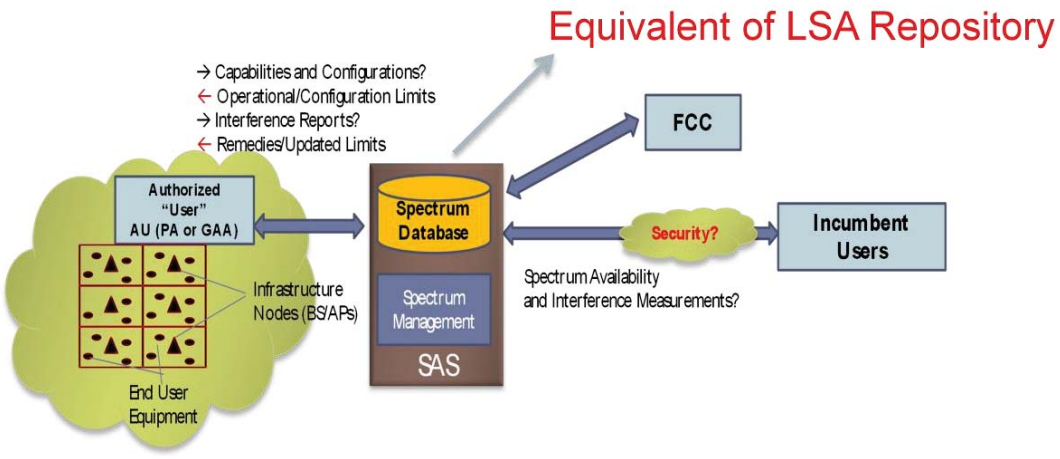

Figure 1: FCC's 3.5GHz SAS

The SAS should contain the relevant information on spectrum available for use by licensees (in the spatial, frequency and time domains). It may add safety margins and deliberate distortions to the free spectrum in order to mask the true activity of the incumbent. The main rationale for this is that the incumbent may not be willing to give precise information about its spectrum use to the

[4] Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band, GN Docket No. 12-354, *Public Notice*, FCC 13-144 (rel. Nov. 1, 2013) ("Revised Framework Public Notice").
[5] *See* Revised Framework Public Notice, ¶¶ 42-48.
[6] *See* Comments of Nokia Siemens Networks US LLC in GN Docket No. 12-354 (Feb. 20, 2013).

Authorized Users like Priority Access Licensees (PALs), for several very good reasons mainly connected to the nature of its service, *e.g.*, defense operations, interference management, network security, emergency services or privacy. There could be one or more repositories. The ASA Repository may be directly managed by the regulator or the incumbent, or be delegated to a trusted third party.

2. LSA/PA controller

The external SAS should not configure and/or set limits on various radio parameters to maximize efficient use of the band. This configuration should be left to the Priority Access ("PA") users, especially MNOs, through the use of a Controller similar to the one that NSN presented as part of its ASA/LSA proposal[7] that could be used in 3550-3650 MHz to manage spectrum sharing between Federal incumbents and Priority Access users. The reasons why NSN recommends that a Controller function sitting inside a PA network, and not the external SAS, configures the network parameters include:

- Such configuration process requires deep insights into the PA licensee's radio access network (RAN).
- Such configuration requires access to information that is business sensitive for the PA licensee.
- There are many parameters to be configured taking into account the entire network layout and interactions of Base Stations (BSs), which is best managed by the network operator.
- The PA network operator must have control to optimize traffic in its network.
- There is a real danger of "mis-configuration" from an external entity like the SAS.
- There are various internal elements to a network that an external SAS cannot and should not oversee.

However, the PA licensee should be responsible for compliance with technical requirements obtained from the SAS such as meeting certain interference thresholds. This can be accomplished via the Controller under the full control of the PA network operator.

The ASA/LSA/PA Controller manages the access to the spectrum made available to the ASA/LSA/PA licensee based on rules built upon ASA/LSA/PA rights of use and information on the incumbent's use provided by the Repository or SAS. It retrieves information about available shared spectrum from the SAS or Repository through a secure and reliable communication path and propagates the permission or prohibition of use of the shared spectrum to the radio access network (RAN). There could be one or multiple ASA/LSA/PA Controllers for each ASA/LSA/PA licensee. The Controller can interface with one or multiple ASA/LSA/PA Repositories. On a more technical view the ASA/LSA/PA controller uses the information from the SAS or repository to provide parameters to the Priority Access licensee's network (*e.g.*, the MNO in Figure 2 below).

In summary, the main targets of the LSA/PA controller are to:

- protect the Operator Network against unauthorized access
- automate the operation of shared spectrum as far as possible
- guarantee a high reliable and secure operation

[7] *Id.*

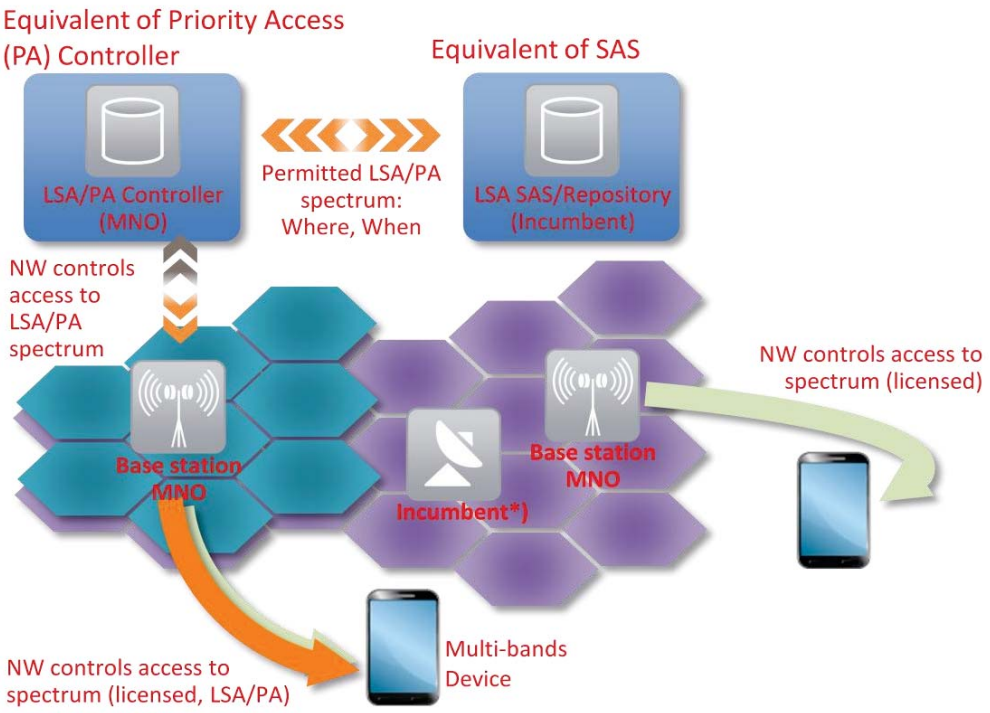

Figure 2: Example of ASA/LSA architecture mapped onto SAS

Due to the sensitivity of data between the SAS and the controller, it is obvious that the SAS and the LSA/PA controller provide extensive authentication and authorization functions to protect and secure the ASA data and the Mobile Operator network.

The LSA/PA controller connects to the SAS and requests the usage data. After successful authentication and authorization, the SAS provides this data to the LSA/PA Controller. The LSA/PA Controller stores the usage data in the Operator Network and initiates a Network Planning process for the shared spectrum. The output of such a network planning are a list of base stations and the respective configuration data for each base station that can use the shared spectrum according to the agreements with the Incumbent. These configuration data are deployed to the RAN network via the Configuration Management. After the successful configuration the ASA spectrum usage needs to be activated or deactivated.

The LSA/PA Controller has to check if the Incumbent has granted the right to use the shared spectrum. It does not matter whether the Controller requests the data from the SAS or the SAS informs the LSA/PA Controller autonomously. In case that the Incumbent requests the MNOs to stop using the shared spectrum, the LSA/PA Controller has to initiate the respective measures to stop the usage of the shared spectrum.

Based on the proximity to Operation and Maintenance (OAM) functions, there are several options how the LSA/PA Controller could be integrated into an Operator's Network. The LSA/PA controller might be a software add-on to a Network Management System or a dedicated server

with the respective functionality and integration interfaces to OAM Systems. Based on the information that is delivered by the SAS, it is obvious that OAM processes and procedures will play a central role. At least two possible OAM tasks for LSA/PA spectrum usage can be distinguished:

- Configuration and network deployment -

The inputs from the SAS and current network data of the mobile operator are used to do classic network planning for the shared spectrum. Output data of the network planning process are configuration parameters for the shared spectrum, which are deployed to the respective Base Stations via OAM systems. There is no need for a near real time process but it is necessary to support multivendor Base Stations due to typical mobile operator networks.

- Shared spectrum activation and deactivation -

Whenever the incumbent requests a stoppage in the use of parts or the entire shared spectrum, it is necessary to evacuate the shared spectrum in the mobile network. Detailed parameters regarding evacuation time, evacuation procedures, *etc.* could be defined between the incumbent and the mobile operator. Functions are needed to support levels of evacuation and the corresponding re-assignment of shared resources, *e.g.*:

- graceful evacuation (for example handover of UEs that use shared resources to mobile operator exclusively owned resources)
- fast evacuation
- planned evacuations.

At least for fast evacuation there is a need for reliable and near real time processing even accepting service interruption of the UE although this obviously is not a preferred solution for the operators. It is not clear yet if all functions could be provided as OAM-only tasks or if a combination of OAM and Core Network functionality provides at least better solution options. With involvement of the Core Network it is, for example, much easier to initiate handovers for the graceful evacuation than to develop an “OAM-only” based solution.

The following functions have also been identified to be quite helpful:

- Carrier Aggregation (shared Carrier as secondary serving cell)
- SON methods for Energy Saving (graceful evacuation mechanisms)

SAS Monitoring and Management of Spectrum Use

(FCC Focus Area C)

One of the requirements for establishing a suitable spectrum sharing arrangement is a reasonably well defined geographical boundary beyond which the incumbent may experience interference from the alternate spectrum user but it is tolerable in that the level is below a threshold that could be deemed as harmful interference. On one hand, the incumbent user will want to ensure that no harmful interference to its systems occurs and so would tend to set the geographic boundary conservatively resulting in a large exclusion or coordination zone. On the other hand, the alternate spectrum user will seek to maximize the area where it can use the spectrum to maximize its economic value of the spectrum. This leads to the need to find a suitable compromise in how the geographic boundaries for sharing the spectrum are defined.

It has been suggested that an interference threshold that may not be exceeded might be defined to aid in the establishment of that geographic boundary. This interference threshold might take a few different forms. Examples include a maximum signal level in dBm or microvolts per meter, or a maximum power spectral density in Watts per MHz. Another option is to establish a suitable minimum S/I (Signal to Interference) ratio that must be maintained between the incumbent and alternate user's systems. Considerations also need to be given to co-channel interference as well as adjacent channel interference.

On the surface, some sort of threshold seems to be a reasonable approach but in practice this will be challenging for systems that are dynamic and mobile. By way of example, the TV White Space solution relies on a signal strength calculation based on the fixed location of TV broadcast stations to assess minimum interference thresholds. The signal contours are generally well behaved at the lower frequencies (below 1 GHz) used by TV stations and do not experience as rapid a change in level in and around buildings and foliage as does the signal from incumbent sources in the microwave regions such as the 3.5 GHz Band. Additionally, the TV stations generally have a fixed antenna pattern and power that is predictable. Some of the incumbent systems such as ship borne or mobile RADAR systems or airborne systems may have variable antenna patterns, variable power transmissions and may not always be fixed in location. Likewise, the alternate user of the shared spectrum may have users that are not fixed in location. They can be outdoors at street level, in the upper floors of a high rise building or inside a home even if the host small cell for those users is at a fixed location with predictable power and antenna pattern. Each of these locations will have different propagation conditions to the incumbent systems making it challenging to predict acceptable thresholds and ultimately which transmitters of the alternate user of the shared spectrum must be turned off, reduced in power or moved to a different frequency at a given location.

NSN believes that methods to determine acceptable thresholds used to determine when and where the shared frequency may be used by an alternate user of the spectrum can start by calculating signal strength and interference levels based on available propagation models and will be refined and further evolve over time. Initial deployments may start with conservative solutions to ensure the lowest probability of interference to the incumbent systems. Over time we expect a more statistical approach to be adopted where some interference might occur a very small percentage of the time and in a small number of locations and the systems can adapt in various

ways to address those cases. Cellular systems, by way of example, are designed to accept interference not only between cells of the same operator but also at boundary locations between operators for co-channel and adjacent channel conditions. Sometimes special systems engineering techniques are used to design the system to achieve acceptable interference thresholds. A requirement that absolutely no interference is allowed is not very realistic. Tolerable interference should be at such a level that the proper function of the incumbent system is not affected. So one of the challenges will be to determine acceptable levels of interference and seek to set thresholds and even adapt the systems for maximum commercial use of the spectrum when sharing it with incumbent users. NSN believes the best way to maximize spectrum sharing opportunities over the long run is with a joint effort between industry and incumbent users to determine the optimal solutions.

Issues Related to Initial Launch and Evolution of SAS and Band Planning

(FCC Focus Area D)

The Commission's Revised Framework PN sought comment on a band plan that balances SAS-enabled General Authorized Access (GAA) use with Priority Access (PA) exclusive use. NSN believes that to best address this situation, the Commission should take a holistic view and also consider its following questions collectively:

- Would a GAA "floor" in each area encourage widespread GAA deployment and operation and should that floor be a minimum of, e.g., 40 or 50 percent of available bandwidth?
- Whether and how the Revised Framework could be extended to the 3650-3700 MHz band and if special provisions would need to be made for incumbent operators?
- Should Critical Users (*e.g.*, hospitals) receive interference protections within a limited portion (*e.g.,* 20 MHz) of the spectrum inside the confines of their facilities?
- The PN further seeks comment on whether such use would require special RF shielding around eligible facilities to provide interference protection.

In addition, the Commission should also consider the fact that the 3.5 GHz band likely will be the first band where sharing with incumbent Federal government users such as Department of Defense (DoD) radars will be required on a large scale. The Commission therefore should take the necessary steps to ensure that the sharing in this band is a success, meaning that both the incumbents and the proposed Citizens Broadband Service users can use the band to fulfill their missions while providing "adequate interference protection for Federal users, especially users with national security, law enforcement, and safety-of-life responsibilities."[8] If the sharing in this band is successful, 3.5 GHz could pave the way for other federal government bands to be opened for commercial use in a shared manner. The Commission should therefore consider a simplified framework for sharing while still providing spectrum for Priority Access and GAA users.

[8] *See* The White House Office of the Press Secretary, President Obama's "*Memorandum for the Heads of Executive Departments and Agencies*" (June 14, 2013).

There are potentially four categories of users that need to share the spectrum:

1. Incumbents such as high powered DoD radars and non-federal Fixed Satellite Service (FSS) earth stations.
2. Priority Access Critical users such as hospitals, utilities, *etc.*
3. Priority Access Non-Critical users such as Mobile Network Operators.
4. GAA users.

In addition to sharing spectrum among these 4 categories of users, each category will have multiple users that need to coexist (*e.g*., multiple hospitals, multiple operators, *etc*.). The GAA users would be authorized to use the 3.5 GHz Band opportunistically within designated geographic areas and have to always accept harmful interference from incumbents and Priority Access users, meaning there is no guarantee for a minimum Quality-of-Service ("QoS"). On the other hand, the incumbents and Priority Access users are entitled to interference protection which should provide a guarantee of a minimum QoS.

Mitigating interference among Priority Access (PA) Users or between PA and GAA Users.

Managing these four categories of users while ensuring that incumbent users can be protected will be complex. There are various ways of mitigating interference among the multiple PA users or between PA and GAA users such as separating the users in time, geography or frequency and/or providing shielding around eligible buildings. For instance, the Revised Framework PN sought comment on whether special RF shielding around eligible Critical Users facilities such as hospitals would provide interference protection. While this measure might be possible, there is a cost associated with shielding or upgrading buildings. In addition, there can still be some residual interference through windows, *etc.* One of the best ways of mitigating interference, therefore, is to separate the users in the frequency domain. A possibility NSN recommends the Commission consider is the following:

- Allocate only 3650-3700MHz for GAA use.

This would provide GAA users with 50 MHz of contiguous spectrum. It would align with the Commission's goals of allocating a minimum amount of spectrum to GAA users in all markets and including the existing 3650-3700 MHz band in the Revised Framework. Within 3650-3700 MHz, GAA users could be afforded access to contiguous blocks of spectrum that can be aggregated.

In addition, existing or new non-exclusive licensees in 3650-3700 MHz could continue to operate under the current regulatory framework governing that band[9] but requiring interference protection from GAA users. This would provide certainty and avoid transition cost to the 3650-3700 MHz licensees if they were to transition to the new Citizens Broadband Service regime. In addition, the 3650-3700 MHz licensees could still have Priority Access to 3550-3650 MHz through the Priority Access Licenses (PALs). The 3650-3700 MHz licensees would benefit from the new ecosystem that is likely to develop with 3GPP TDD Band 43 that covers 3600-3800 MHz. Economies of scale could drive down the price of equipment for current 3650-3700 MHz licensees and future licensees, making it more affordable for new and existing operators to expand their service

[9] *See* 47 C.F.R. Part 90 Subpart Z; Wireless Operations in the 3650-3700 MHz Band, ET Docket No. 04-151, *Report and Order and Memorandum Opinion and Order*, 20 FCC Rcd 6502 (2005) (*3650-3700 MHz Report and Order and Memorandum Opinion and Order*).

offerings. The main incumbents in 3650-3700 MHz are Fixed Satellite Service (FSS) earth stations. When the Commission authorized the shared use of 3650-3700 MHz it adopted 150 km exclusion zone around grandfathered FSS earth stations but also allowed licensees in 3650-3700 MHz to negotiate with individual FSS earth station licensees for smaller exclusion zones. An exclusion zone can similarly be used to protect the incumbent FSS earth stations from GAA users without the use of the Spectrum Access System (SAS). Its size will need to be determined based on further study. However, the SAS could be used in 3650-3700 MHz to enable spectrum sharing between the non exclusive licensees and GAA users. Having GAA users restricted to 3650-3700MHz would also mitigate any interference risks from GAA users to Federal Government users in 3550-3650MHz.

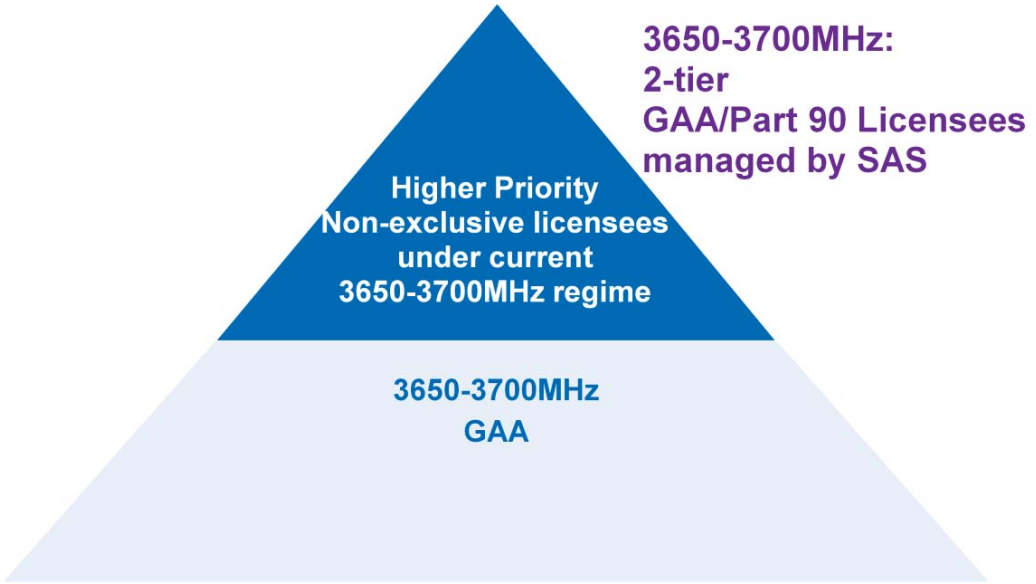

Figure 3: 3650-3700MHz, 2-Tier Non-Exclusive Licensees/GAA users managed by SAS

- Allocate 3550-3650 MHz for Priority Access Use only, and not GAA.

Allocating a minimum amount of spectrum to GAA use in 3550-3650 MHz potentially would mean less spectrum available for Priority Access use in 3550-3650 MHz. For instance, if 40% of the bandwidth is allocated to GAA, only 60MHz is available to Priority Access users in 3550-3650 MHz. Moreover, this spectrum would need to be shared between critical users (*e.g.*, hospitals) and non critical users (*e.g.,* MNOs) at a given location. In addition, when the incumbents are using the spectrum, there can be restrictions on the use of the spectrum by the PA licensees. Further, with TDD operation, some level of coordination is necessary to avoid the use of guard bands between different operators/users on adjacent PALs. Critical Users (*e.g.*, hospitals) could also be allocated a specific 20 MHz of spectrum inside the confines of their facilities. With critical users confined within their facilities, there is a higher probability that this 20 MHz of spectrum could be reused by different critical users because of the isolation provided by the buildings,

separation distances between the critical users, *etc*. However, there could still be interference from and to non-critical users like MNOs which have deployed their systems just outside of those buildings. This can be particularly true for dense urban areas where a hospital could be located just off a street where operators have deployed small cells on lamp posts, *etc*. In those cases, the operators might not be able to use the 20 MHz that the hospital is using and therefore only the remaining 80 MHz would be available to the non-critical operators. This is still larger than a 40% GAA/60 % PA split in 3550-3650 MHz.

For all of these reasons, the spectrum available to PALs should be maximized. The best way to do this is to not allocate any GAA use in 3550-3650 MHz. NSN anticipates that in this model which provides more certainty, essentially all of the PALs will be used and there is no need for the SAS to automatically make that spectrum available for GAA use locally. Should this prediction not prove true, the Commission could revisit at a future time whether to allow GAA use in this portion of the band. Taking this approach would provide 100 MHz of contiguous spectrum for PALs, allowing for the possibility of multiple licensees having access to significant amounts of spectrum. NSN also recommends that individual PAL licensees be able to obtain contiguous blocks of spectrum that they can aggregate together.

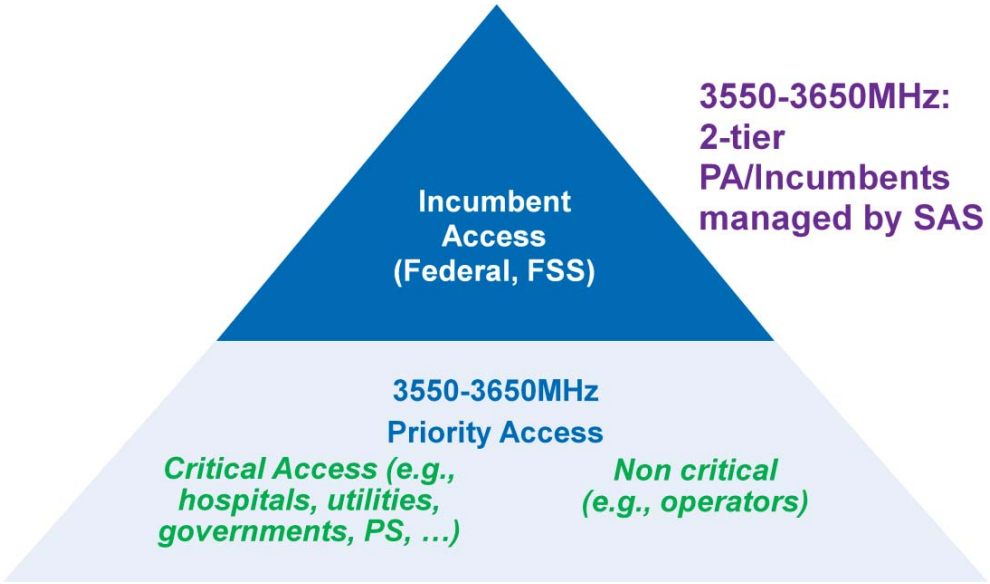

Figure 4: 3550-3650MHz, 2-Tier Incumbents/Priority Access users managed by SAS, no GAA

NSN therefore offers its vision for a Revised Framework as shown in Figure 5 for consideration by the Commission that would help achieve the Commission's goals of allowing "productive" use of the spectrum while protecting the PA users and Incumbents:

- Expand PA tier to include non-critical users like MNOs in 3550-3650 MHz. Manage incumbents/PA by the SAS. Allow GAA use in 3650-3700 MHz and afford non-exclusive licensees higher priority than GAA. Manage non-exclusive licensees/GAA by the SAS.

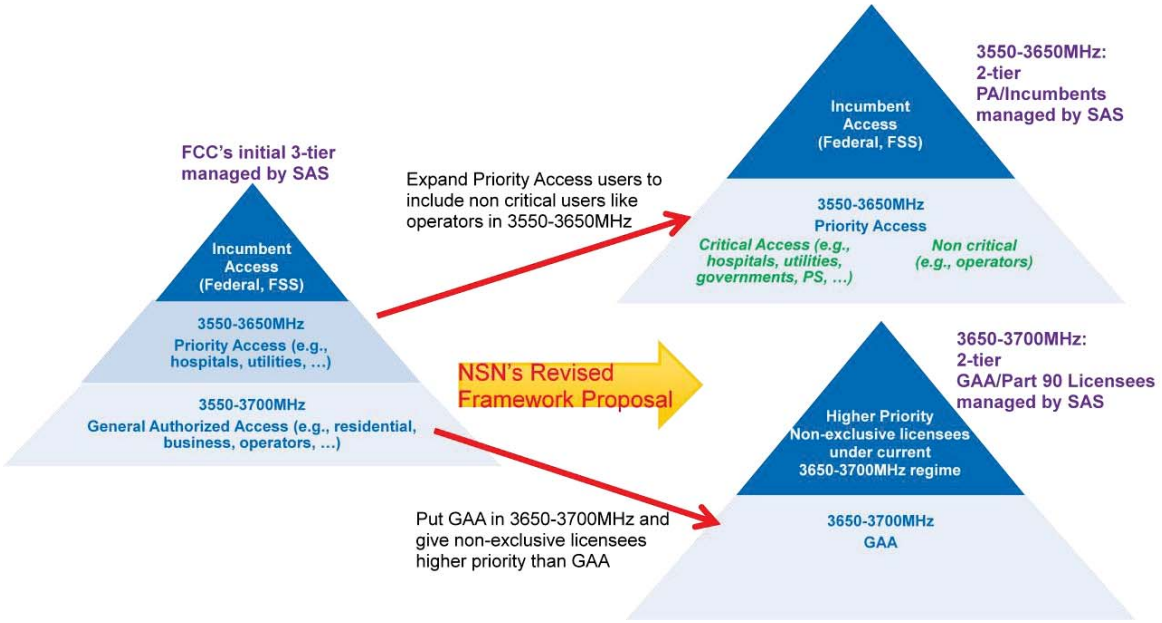

Figure 5: NSN's Revised Framework Proposal

Conclusion

Nokia Solutions and Networks is encouraged by the Commission's ongoing and evolving efforts that represent progress towards enabling the availability of the 3.5 GHz Band for use in the provision of mobile broadband services. While cleared, exclusively licensed spectrum remains the top priority for the commercial wireless industry, the 3.5 GHz Band has some unique characteristics that promise to make licensed sharing a viable and interesting proposition in this particular instance.

NSN strongly supports the Commission's Revised Framework's proposal to provide open access to a Priority Access (PA) tier for any entity interested in operating in a quality-of-service environment, including importantly mobile network operators that are feeling the effects of constantly escalating consumer demand for improved mobile broadband speeds and coverage. Such a PA tier functionally is equivalent to NSN's proposed ASA/LSA tier.

The fundamental message from NSN on the SAS is that the Commission should define only the general responsibilities and composition of the SAS with the detailed requirements defined by industry groups and standardization bodies that ideally include participation by the incumbent spectrum users, mobile operators, other potential new users, suppliers, and regulators. For the reasons mentioned throughout this paper, NSN envisages that the SAS should only contain the relevant information on spectrum available for use by licensees (in the spatial, frequency and time domains). The SAS should not configure and/or set limits on various radio parameters to maximize efficient use of the band. This configuration should be left to the Priority Access users, especially MNOs, through the use of a Controller function similar to the one that NSN presented as part of its ASA/LSA proposal that could be used in 3550-3650 MHz to manage spectrum sharing between Federal incumbents and Priority Access users. However, the PA licensee should be responsible for compliance with technical requirements obtained from the SAS such as meeting certain interference thresholds.

When it comes to band planning, NSN believes that allowing only PA in the 3550-3650MHz band would maximize the number of PA licenses that can then serve the needs of both critical and non-critical licensees while ensuring that the incumbent Federal users are protected. Additionally, NSN supports expanding the Revised Framework to include 3650-3700 MHz to make a total of 150 MHz available and enable essentially a 50 MHz “sand box” for GAA use in 3650-3700 MHz while providing higher priority status and protection to current and future licensees that operate in this band under Part 90, Subpart Z of the Commission’s rules.

NSN believes that these measures as a whole would provide the right combination to enable commercial success and foster innovative experimentation in the entirety of the 3550-3700 MHz spectrum range. Depending upon how utilization of the band develops and matures in the coming years, the Commission of course could revisit at a future time whether to allow GAA use within 3550-3650 MHz or make other adjustments to the framework.

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